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Indian Standard
MATERIALS FOR LIGHT DUTY SPRINGS FOR INSTRUMENT INDUSTRY

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Indian Standard

MATERIALS FOR LIGHT DUTY SPRINGS FOR INSTRUMENT INDUSTRY

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 18 December 1980, after the draft finalized by the Optical and Mathematical Instruments Sectional Committee had been approved by the Mechanical Engineering Division Council.

0.2 This standard is intended to provide guidance for the selection of materials used for the manufacture of light duty metallic springs for instrument industry. Except for special components like hair springs used exclusively by the watch industry almost all other materials have been covered in this standard.

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1. SCOPE

1.1 This standard gives at a glance the important characteristics and chemical composition of the various materials used for the manufacture of light duty metallic springs for instrument industry.

NOTE—This standard, except in special cases, is not intended to be quoted on drawings or on orders. The absolute suitability of the material for a specific application should be examined in detail along with its relevant published standard.

2. MATERIAL

2.0 Majority of springs are made from wires of high carbon or alloy steels in oil-hardened and tempered or in hard-drawn condition in the smaller sizes and hot-rolled high carbon or alloy steel in larger sizes, heat-treated after forming.

2.1 Where corrosion is a problem stainless steel is widely used.

2.2 Most of the common spring materials shall perform satisfactorily at temperature as low as —20°C. Below this temperature high carbon steels tend to become brittle. High nickel alloys may be used without fear of such embrittlement.

2.2.1 All non-ferrous spring materials (phosphor bronze, Monel, Inconel, etc) and stainless steel give satisfactory service at temperatures as low as —50°C.

2.3 For elevated temperature applications, depending on the temperature range, spring materials like Monel, Inconel, etc, are commonly used.

2.4 If high electrical conductivity is required phosphor bronze and beryllium-copper may be used.

3. SELECTION OF MATERIALS

3.1 Selection of materials shall be based on seeking the best behaviour in application involving corrosive atmosphere, elevated temperature shock or impact loading and physical characteristics for longest endurance under highly stressed conditions. Chemical composition, properties and possible applications of various materials are given in Appendices A to F.

3.2 The materials have been classified under six categories.

3.2.1 *High Carbon Steels* — High carbon steels are the most commonly used of all spring materials. These are less expensive, readily available and easily workable. These materials are not satisfactory for high or low temperatures or for shock or impact loading (*see* Appendix A).

3.2.2 *Alloy Spring Steels* — The alloy spring steels may be used for conditions involving high stress and for applications where shock or impact loading occurs. These can also withstand both higher and lower temperatures than the high carbon steels and are obtainable in either annealed or pretempered conditions (*see* Appendix B).

3.2.3 *Stainless Spring Steels* — Several compositions of stainless steels are available to withstand corrosion. All of these materials may be used for high temperatures up to 250°C. For subzero temperature, however, only stainless steel wire Grade 1 may be used (*see* Appendix C).

3.2.4 *Copper-Base Spring Alloys* — Copper-base spring alloys have good electrical properties combined with their excellent resistance to corrosion and are frequently used in electrical components and in subzero temperatures. These are non-magnetic (*see* Appendix D).

3.2.5 *Nickel-Base Spring Alloys* — Nickel-base alloys are especially useful spring materials to combat corrosion; to withstand both elevated and subzero temperature applications and their non-magnetic characteristic is important for such devices as gyroscopes, chronoscopes, and indicating instruments. These materials have high electrical resistance and should not be used for conductors of electrical current (*see* Appendix E).

3.2.6 *Constant-Modulus Alloys* — Special nickel alloys having a constant-modulus of elasticity over a wide temperature range are highly desirable for springs subjected to temperature changes; especially where the springs must exert uniform loads and deflections. These materials having a low or zero thermoelastic coefficient eliminate variations in the stiffness of springs caused by modulus value changes due to temperature differentials (*see* Appendix F). These corrosion resistant alloys having uniform and nearly constant elastic characteristics also have low hysteresis and low creep values, making them preferred materials for food weighing scales, precision instruments, gyroscopes, measuring devices, recording instruments and computing scales where temperature changes are within the range of —45°C to 65°C.

APPENDIX A

(*Clauses* 3.1 *and* 3.2.1)

HIGH CARBON STEELS

Sl No.	Designation/Grade of Material	Chemical Composition, Percent						Tensile Strength (*See* Note)	Maximum Working Temperature	Possible Applications	Relevant Indian Standard
		C	Si	Mn	S *Max*	P *Max*	Cu *Max*				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
								MPa	°C		
1.	Cold-drawn steel wire										
	a) Grade 1	0·50-0·75	0·15-0·35	1·0	0·050	0·040	0·12	980-1 720	120	Helical springs, spring rings and wire forms. For springs subjected to static or low load cycles—low stressed	IS : 4454 (Part I)-1975*
	b) Grade 2	0·60-0·85	0·15-0·35	0·8	0·040	0·040	0·12	950-2 060	120	For springs subjected to moderate load cycles—moderately stressed	IS : 4454 (Part I)-1975*
	c) Grade 3	0·75-1·0	0·15-0·35	0·8	0·030	0·030	0·12	1 290-2 550	120	For highly stressed static springs, for springs under moderate to high dynamic stresses and in smaller diameter even for impact loaded springs	IS : 4454 (Part I)-1975*
	d) Grade 4	0·75-1·0	0·15-0·35	0·8	0·025	0·025	0·12	1 480-2 700	120	For highly stressed static springs and moderately stressed dynamic springs	IS : 4454 (Part I)-1975*
2.	Oil-hardened and tempered steel wire										
	a) Grade SW	0·55-0·75	0·15-0·35	0·60-0·90	0·040	0·040	0·10	1 250-1 960	170	Used for moderately stressed springs	IS : 4454 (Part II)-1975†
	b) Grade VW	0·60-0·70	0·15-0·35	0·60-0·90	0·020	0·025	0·06	1 300-1 810	150	Used for springs under high dynamic stressed and for impact loaded springs	IS : 4454 (Part II)-1975†

3. Carbon steel wire										
a) C 65	0·60-0·70	0·35 *Max*	0·50-0·80	0·050	0·050	—	930-2 450	150	Used for a wide variety of general purpose springs	IS : 1570-1961‡
b) C 75	0·70-0·80	0·35 *Max*	0·50-0·80	0·050	0·050	—	930-2 450	150	Selection depends upon size and duty it has to perform	NOTE — These materials are also likely to be included in the second revision of IS : 1570 (Part II)-1979§
c) C 85	0·80-0·90	0·35 *Max*	0·50-0·80	0·050	0·050	—	930-2 450	150		
4. Cold-rolled steel strip										
a) 45C 8	0·40-0·50	0·10-0·35	0·60-0·90	0·050	0·050	—	590-1 420	150	Miscellaneous flat springs, clock and motor springs, static load springs, etc	IS : 2507-1975‖
b) 55C 6	0·50-0·60	0·10-0·35	0·50-0·65	0·050	0·050	—	590-1 420	150		
c) 65C 6	0·60-0·70	0·10-0·35	0·50-0·80	0·050	0·050	—	590-1 420	150		
d) 70C 6	0·65-0·75	0·10-0·35	0·50-0·80	0·050	0·050	—	640-1 570	150		
e) 75C 6	0·70-0·80	0·10-0·35	0·50-0·80	0·050	0·050	—	640-1 570	150		
f) 80C 6	0·75-0·85	0·10-0·35	0·50-0·80	0·050	0·050	—	640-1 570	150		
g) 85C 6	0·80-0·90	0·10-0·35	0·50-0·80	0·050	0·050	—	640-1 570	150		
h) 98C 6	0·90-1·05	0·10-0·35	0·50-0·80	0·050	0·050	—	690-1 770	150	For high stresses clock and motor springs. Withstand higher stresses than other cold-rolled steel strips. Main spring of watches or similar devices	IS : 2507-1975‖

NOTE — $1\ \text{MPa} = \frac{1\ \text{MN}}{\text{m}^2} = \frac{1\ \text{N}}{\text{mm}^2}$.

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*Specification for steel wires for cold formed springs: Part I Patented and cold-drawn steel wires—unalloyed (*first revision*).

†Specification for steel wires for cold formed springs: Part II Oil-hardened and tempered spring steel wire and value spring wire—unalloyed (*first revision*).

‡Schedules for wrought steels for general engineering purposes.

§Schedules for wrought steels: Part II Carbon steels (unalloyed steel) (*first revision*).

‖Specification for cold-rolled steel strips for springs (*first revision*).

APPENDIX B

(*Clauses* 3.1 *and* 3.2.2)

ALLOY SPRING STEELS

SL No.	DESIGNATION/GRADE OF MATERIAL	CHEMICAL COMPOSITION, PERCENT							TENSILE STRENGTH (*see* NOTE)	MAXIMUM WORKING TEMPERATURE	POSSIBLE APPLICATIONS	RELEVANT INDIAN STANDARD
		C	Si	Mn	S *Max*	P *Max*	Cr	V				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
									MPa	°C		
1.	Chromium-vanadium steel wires											
	a) Grade 1S	0·45-0·55	0·15-0·35	0·60-0·90	0·040	0·040	0·90-1·20	0·15-0·30	1 470-1 860	220	Grade 1S and 2S used for static working springs and Grade 1D and 2D for dynamic. For conditions involving high stresses and where fatigue and long endurance are needed. For springs to withstand impact or shock loadings; recoil springs in dies and pneumatic hammer	IS : 4454 (Part III)-1975*
	b) Grade 1D	0·45-0·55	0·15-0·35	0·60-0·90	0·020	0·020	0·90-1·20	0·15-0·30	1 420-1 760	200		
2.	Silicon-chromium steel wire											
	a) Grade 2S	0·50-0·60	1·20-1·60	0·50-0·80	0·040	0·040	0·50-0·80	—	1 670-1 960	300		
	b) Grade 2D	0·50-0·60	1·20-1·60	0·50-0·80	0·025	0·025	0·50-0·80	—	1 670-1 960	280		
3.	Silicon-manganese steel wire											
	55Si2Mn90	0·50-0·60	1·50-2·00	0·80-1·00	0·050	0·050	—	—	1 370-1 720	200	Used particularly as a substitute for chromium-vanadium steels. They exceed the chromium-vanadium steels in heat resistance	IS : 1570-1961†
4.	Cold-rolled steel strip											
	a) 55Si7	0·50-0·60	1·50-2·00	0·80-1·00	0·050	0·050	—	—	1 570-1 960	200	Same as Sl No. 3. Specially recommended for heavy flat leaf cantilever springs	IS : 2507-1975‡
	b) 50Cr4	0·45-0·55	0·10-0·35	0·60-0·90	0·050	0·050	0·90-1·20	—	1 670-2 260	200	Same as Sl No. 1	
	c) 50Cr4V2	0·45-0·55	0·10-0·35	0·50-0·80	0·050	0·050	0·90-1·20	0·15-0·30	1 880-2 360	200	Same as Sl No. 1	

NOTE — 1 MPa = $\frac{1\ \text{MN}}{\text{m}^2} = \frac{1\ \text{N}}{\text{mm}^2}$.

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*Specification for steel wires for cold formed springs: Part III Oil-hardened and tempered steel wires—alloyed (*first revision*).

†Schedules for wrought steels for general engineering purposes.

‡Specification for cold-rolled steel strip for springs (*first revision*).

APPENDIX C

(*Clauses* 3.1 *and* 3.2.3)

STAINLESS SPRING STEELS

SL No.	DESIGNATION/GRADE OF MATERIAL	CHEMICAL COMPOSITION, PERCENT								TENSILE STRENGTH (*see* NOTE)	MAXIMUM WORKING TEMPERATURE	POSSIBLE APPLICATIONS	RELEVANT INDIAN STANDARD
		C	Si *Max*	Mn *Max*	Cr	Ni	P *Max*	S *Max*	Others				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
										MPa	°C		
1.	Stainless steel wire												
	i) Austenitic steel												
	a) Grade 1	0·15, *Max*	1·00	2·00	17·0-19·0	8·0-10·0	0·045	0·030	—	1 270-2 060	250 and also suitable for subzero temp	High tensile strength and quite uniform properties. Cannot be hardened by heat treatment; non-magnetic when fully annealed, slightly magnetic due to cold working. Corrosion resisting	IS : 4454 (Part IV)-1974*
	b) Grade 2	0·09, *Max*	1·00	1·00	16·0-18·0	6·75-7·75	0·040	0·030	Al(0·75-1·25)	1 270-2 060	350		
	ii) Martensitic steels												
	a) 04Cr13	0·08, *Max*	1·0	1·0	11·5-14·5	—	0·040	0·030	Al(0·10-0·30)	480, *Min*	250	Less severe corrosive conditions than the austenitic steels. Require hardening and tempering after forming	IS : 6528-1972†
	b) 12Cr13	0·09-0·15	1·0	1·0	11·5-14·0	1·0, *Max*	0·040	0·030	—	480, *Min*	250		
2.	Stainless steel strips												
	a) 07Cr18Ni9	0·12, *Max*	1·0	2·0	17·0-19·0	8·0-10·0	—	—	—	490-690	250	Same as in Sl No. 1(i)	IS : 1570 (Part V)-1972‡
	b) 04Cr18Ni10Ti20	0·08, *Max*	1·0	2·0	17·0-19·0	9·0-12·0	—	—	Ti(5C-0·80)	490-690	250		
	c) 04Cr18Ni11	0·08, *Max*	1·0	2·0	17·0-20·0	9·0-13·0	—	—	—	490-690	250		
	d) 04Cr18Ni10Nb40	0·08, *Max*	1·0	2·0	17·0-19·0	9·0-12·0	—	—	Nb(10C-1·0)	490-690	250		

NOTE — 1 MPa $= \frac{1\ \text{MN}}{\text{m}^2} = \frac{1\ \text{N}}{\text{mm}^2}$.

*Specification for steel wires for cold formed springs : Part IV Stainless spring steel wire for normal corrosion resistance.
†Specification for stainless steel wire.
‡Schedules for wrought steels: Part V Stainless and heat-resisting steels.

APPENDIX D

(*Clauses* 3.1 *and* 3.2.4)

COPPER BASE SPRING ALLOYS

Sl No.	Designation/Grade of Material	Chemical Composition, Percent							Tensile Strength (*see* Note)	Maximum Working Temperature	Possible Applications	Relevant Indian Standard
		Sn	Cu	Pb	Fe	Total Impurities	Be/P	Zn				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10) MPa	(11) °C	(12)	(13)
1.	Spring brass wire CuZn34	—	64-67	0·1, *Max*	0·1, *Max*	0·4, *Max*	—/—	Rem	690-820	65°C and also suitable at subzero temperature	High electrical conductivity. Low tensile strength and poor spring quality, but extensively used where sharp bends are needed. Non-magnetic	IS : 4076-1967*
2.	Phosphor bronze wire											
	a) Grade I	4·6-5·5	Rem	0·05, *Max*	—	0·20, *Max*	—/0·02-0·40	—	340-850	100°C and also suitable for subzero temperature	Most popular of this group as it combines the best qualities of tensile strength, hardness, electrical conductivity and corrosion resistance. Can withstand stress 50 percent higher than brass. Used for contact fingers in switches	IS : 7608-1975†
	b) Grade II	5·6-7·5	Rem	0·05, *Max*	—	0·20, *Max*	—/0·02-0·40	—	370-900	do		
3.	Beryllium copper wire	—	Rem	—	—	Co (0·25), *Max* or Ni (0·2-0·5)	1·85-2·10	—	1 100-1 370	140°C and also suitable for subzero temperature	Used for carrying electrical current in switches and in electrical components	—
4.	Spring brass strip	←							Same as Sl No. 1			→
5.	Phosphor bronze strip											
	a) Grade I	3·0-4·5	Rem	0·02, *Max*	—	0·2, *Max*	—/0·02-0·40	—	295-620	100°C and also suitable at subzero temperature	The condition of these materials is selected according to ductility and working stress requirements. Mechanical properties improve with an increase of tin content for similar amount of cold work. They have good electrical conductivity, moderate corrosion resistance and achieve their mechanical properties by cold working	IS : 7814-1975‡
	b) Grade II	4·6-5·5	Rem	0·02, *Max*	—	0·2, *Max*	—/0·02-0·40	—	310-645	do		
	c) Grade III	5·6-7·5	Rem	0·02, *Max*	—	0·2, *Max*	—/0·02-0·40	—	340-690	do		
6.	Beryllium copper strip	←							Same as Sl No. 3			→

NOTE—$1\ \text{MPa} = \dfrac{1\ \text{MN}}{\text{m}^2} = \dfrac{1\ \text{N}}{\text{mm}^2}$.

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*Specification for hard brass wires for springs and other special purposes.

†Specification for phosphor bronze wires (for general engineering purposes).

‡Specification for phosphor bronze sheet, strip and foil.

APPENDIX E

(*Clauses* 3.1 *and* 3.2.5)

NICKEL BASE SPRING ALLOYS

SL No.	MATERIALS*	CHEMICAL COMPOSITION, PERCENT								TENSILE STRENGTH (*see* NOTE)	MAXIMUM WORKING TEMPERATURE	POSSIBLE APPLICATIONS	RELEVANT INDIAN STANDARD
		Ni	Fe	Al	Mn	C	Si	Cu	Others				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
										MPa	°C		
1.	Monel	63·0-67·0	2·5, *Max*	0·5, *Max*	2·0, *Max*	0·3, *Max*	0·5, *Max*	Rem	S (0·02), *Max*	685-980	200 and also suitable at subzero temperature	Corrosion resistance to sea water; non-magnetic; can be subjected to stresses slightly higher than phosphor bronze and nearly as high as berryllium copper. Used in marine engines and in equipment having contact with food and beverages	—
2.	'K' Monel	63·0-70·0	2·0, *Max*	2·0-4·0	1·0, *Max*	0·25, *Max*	0·50, *Max*	Rem	Ti (0·50) other impurities (1·0), *Max*	980-1 370	230 and also suitable at subzero temperature	Non-magnetic, high spring properties and excellent corrosion resistance. Satisfactory under saline atmosphere	—
3.	Inconel	75·0, *Min*	9·0, *Max*	—	1·0, *Max*	0·15, *Max*	0·30, *Max*	0·50, *Max*	Cr (13·0-16·0)	980-1 180	370 and also suitable at subzero temperature	Most popular in this group, because it is non-magnetic; excellent corrosion resistance and can be used at high temperature. Often used in steam valves, regulating valves and for springs used in boilers, compressors, turbines and jet engines. Satisfactory under saline atmosphere	—
4.	Inconel 'X'	70·0, *Min*	5·0-9·0	0·4-1·0	0·4-1·0, *Max*	0·08, *Max*	0·50, *Max*	0·20, *Max*	S (0·01), *Max* Cr (14·0-16·0) Nb (0·70-1·20) Ti (2·25-2·75)	980-1 080	450 and also suitable at subzero temperature	Same as Sl No. 3	—
5.	Duranickel or 'Z' Nickel	Rem	0·60, *Max*	4·0-4·75	0·25-1·0	0·30, *Max*	1·0, *Max*	0·25, *Max*	S (0·01), *Max*	980-1 275	260 and also suitable at subzero temperature	High nickel alloy, non-magnetic and corrosion resistant. Used for springs to carry electric current at higher temperature	—

NOTE—1 MPa = $\frac{1\ \text{MN}}{\text{m}^2} = \frac{1\ \text{N}}{\text{mm}^2}$.

*The trade names by which these materials are commonly known.

APPENDIX F

(*Clauses* 3.1 *and* 3.2.6)

CONSTANT MODULUS ALLOYS

SL No.	MATERIALS*	CHEMICAL COMPOSITION, PERCENT								TENSILE STRENGTH (*see* NOTE)	MAXIMUM WORKING TEMPERATURE	POSSIBLE APPLICATIONS	RELEVANT INDIAN STANDARD
		Ni	Cr	W	Mn	Si	C	Fe	Others				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
										MPa	°C		
1.	Elinvar	33·0-35·0	4·0-5·0	1·0-3·0	0·5-2·0	0·5-2·0	0·5-2·0	53·0-61·0	—	490	−100 to +150	Used for hair springs in watches, springs for gauges and instruments. Low thermal expansion and almost, invariable modulus of elasticity	—
2.	Ni-Span-C	42·0	5·5	—	—	—	0·06	Rem	Ti (2·5)	1 370	−45 to +120	Used for control, measuring and timing equipment	—
3.	Elgiloy or 8J Alloy or Durapower or Cobenium	15·5	20·0	—	2·0	—	0·15	15·0	Co (40·0) Mo (7·0) Be (0·03)	2 450	500 and also suitable at subzero temperature	Rifles rear springs and for surgical instruments. Non-magnetic and corrosion resistant	—

NOTE—1 MPa $= \frac{1\ \text{MN}}{\text{m}^2} = \frac{1\ \text{N}}{\text{mm}^2}$.

*The trade names by which these materials are commonly known.

INDIAN STANDARDS ON MATERIALS AND COMPONENTS FOR INSTRUMENTS

IS:	
5415-1969	Code of practice for packing and packaging of optical and mathematical instruments and components
7010-1973	Pivots for magnetic compasses
7011-1973	Back-silvered mirrors used in instrument industry
7020-1973	Crystals and dielectric materials used in instrument industry
7047-1973	Timbers used in instrument industry
7078-1973	Plastics used in instrument industry
7265-1973	Coating materials (metals, alloys and dielectrics) used in optical instruments industry
8248-1976	Antireflection coating on glass optical components
8311-1976	Instrument jewels

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